

Cooperative feeding among bottlenose dolphins (*Tursiops truncatus*) near Grand Bahama Island, Bahamas

Kelly Ann Rossbach

Oregon State University, Hatfield Marine Science Center, Newport, OR 97365, USA

Introduction

Dolphins in schools benefit from the mutual detection of predators and prey (Norris & Dohl, 1980). Researchers have observed dolphins cooperating while searching for and capturing prey (reviewed by Leatherwood, 1975, Norris & Dohl, 1980, Würsig, 1986, Bel'kovich *et al.*, 1991). Dolphin schools capture prey by use of two methods: (a) spread-school formation in which dolphins spread out from their group, feeding relatively independently, and (b) cooperative-capture methods, where dolphins work together to help seize prey (Norris & Dohl, 1980). This paper describes observations of cooperative capture by dolphins in the Bahamas.

Methods

I observed cooperative-feeding behaviour of bottlenose dolphins (*Tursiops truncatus*) as part of a photoidentification study of the species in the northwestern Bahamas, between May and September, 1994–1996 (Rossbach, 1997). The study area follows the western edge of Little Bahama Bank (26°42'N, 79°00'W) and the White Sand Ridge (27°15'N, 79°08'W) (Fig. 1). Water depth varies between 1–20 m, and generally increases from south to north. The study area is approximately 280 km², 56 km north to south and about 5 km east to west. It is characterized by mostly sand bottom with small and large patches of turtle grass (*Thalassia testudinum*), and scattered areas of rock and reef.

A dolphin 'sighting' was defined as all dolphins in sight, moving in the same direction, and usually involved in similar activity (termed 'pod' in Shane, 1990). Dolphin sightings were recorded and photographed from a 5.3 m inflatable boat with a 70-hp motor. Time, location, number of dolphins, and description of behaviours were recorded on an audio tape. After photographing dorsal fins from the surface, I occasionally entered the water with snorkel gear to photograph animals underwater, determine dolphin gender, and observe behaviour.

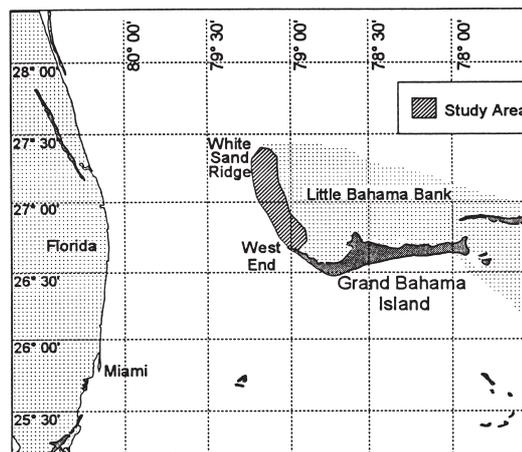


Figure 1. The study area.

Recorded data were transcribed on the evening of the observations. A specific dolphin's 'total sightings' referred to the total number of times a dolphin was photographically identified, including those times other than when cooperatively feeding.

Results

Feeding behaviour was observed during 94 of 295 bottlenose dolphin sightings, between 1994–1996. I observed cooperative-feeding behaviour during 6 of the 94 feeding sightings, in 1995 and 1996 (Table 1). I refer to these six sightings as 'cooperative-feeding sightings'. They averaged 11 dolphins (SD=5, n=6). A total of 79 'bouts' of cooperative-feeding behaviour were seen during the six sightings. A bout began with dolphins swimming rapidly in a dispersed line abreast, occasionally porpoising in water 3–4 m deep. Dolphins at the end of the line swam faster to form a large, loose circle, and continued to swim swiftly toward each other, presumably herding fish to the centre. As the dolphins approached each other, they lunged, and dove

Table 1. Six sightings of cooperatively feeding bottlenose dolphins near Grand Bahama Island

	7/2/95	7/8/95	8/11/95	9/7/95	9/20/95	6/27/96
Time start observation	9:21	11:17	10:40	10:06	12:32	10:20
Time end observation	13:13	17:28	16:37	15:39	17:36	13:04
Start of first bout	9:57	16:27	10:50	10:31	12:57	10:47
Start of last bout	13:09	N/A	15:19	13:57	15:32	11:29
Number of bouts	29	1	19	16	9	5
Number of dolphins	10	13	11	19	10	4
Number of calves*	1	2	2	3	2	1
Number of dolphins photographically identified	8	13	11	18	10	4

*greater than half of adult size, surfacing in echelon position with presumed mother.

synchronously when the circle was about 8–10 m in diameter, producing a circle formation. Dolphins typically remained underwater for 30–90 s (10 durations collected on 7/2/95: \bar{x} =54 s, SD =19, n =10 circle formations). One dolphin usually surfaced briefly one time, several seconds before the others. After the 30–90 s synchronous dive, all dolphins surfaced and dove repeatedly (tail-stock dives and fluke-up dives; Shane, 1990) in the immediate area for 3–5 min. The dolphins then dispersed to begin another bout. Typically, it was 5–10 min between bouts (25 intervals collected on 7/2/95: \bar{x} < min, SD =4, n =25 measured intervals), although periods of up to 90 min occasionally separated them.

During two sightings, immediately after a few circle formations occurred, I positioned the boat within 2 m of the dolphins, and entered the water. Underwater, I observed dolphins in a tight pod form (<1 body length between dolphins; Shane, 1990), facing in various directions, and oriented toward the grassy bottom where they had presumably herded the fish. Clicks (presumably echolocation) were audible in the water. Dolphins moved slowly, and picked small fish (<12 cm) of unidentified species out of the grass. Fish may have been disoriented because they seemed easily caught.

Of 212 bottlenose dolphins photographically identified in the area, 34 individuals (16%) were identified in the six cooperative-feeding sightings. No single dolphin was found in all six sightings. None of the sightings included newborns (approximately half the size of the presumed mother).

Eleven of the 34 dolphins were seen exclusively in cooperative-feeding sightings. Seven others fed cooperatively in 50%–75% of their total sightings. One dolphin was observed cooperatively feeding in two of five total sightings. I refer to these 19 dolphins as 'cooperative feeders'. Cooperative feeders were sighted a total of 1–6 times each (\bar{x} =3.2, SD =1.7, n =19), compared to the overall average number of sightings for dolphins in the study area (\bar{x} =7 sightings per dolphin, n =212 dolphins;

Rossbach & Herzing, in press). Sightings of cooperative feeders were usually located in a heavily searched, southern section of the study area, so their low frequency of occurrence was not attributable to search effort.

The remaining 15 dolphins observed feeding cooperatively were members of a local community, termed 'Southern dolphins' by Rossbach & Herzing (in press). Eleven of the 15 identified dolphins were present in only one bout, yet each was identified a total of 10–27 times during the study. Two of the remaining four dolphins were seen in five bouts during one sighting, and two dolphins (an adult female, and her 2–3 yr-old calf) were present during three sightings. Each of these four dolphins was photographically identified in 16–26 total sightings during the study. Cooperative feeding was rarely observed among the local resident dolphins.

Discussion

Only certain dolphins in the current study were seen to feed cooperatively. Of 212 dolphins identified, only 34 dolphins (16%) were observed cooperatively feeding. Eighteen of these dolphins were seen cooperatively feeding during $\geq 50\%$ of their total sightings, and were only identified a total of 1–6 times each. A small percentage of dolphins occasionally seen in the study area utilize this type of foraging behaviour.

Rossbach & Herzing (in press) distinguished communities of bottlenose dolphins in the study area based on association patterns. They used the Simple Ratio index of association (SR) to describe patterns of association between dolphins in 'fully-photographed sightings', defined as a sighting in which the number of photographically-identified dolphins equalled or exceeded the field estimate, excluding unidentifiable calves. Only four non-calf, cooperative feeders were photographed ≥ 5 times in fully-photographed sightings (the criteria Rossbach & Herzing required for inclusion in the analyses).

Table 2. Reports of presumed cooperation in feeding bottlenose dolphins

Location	No. of Dolphins Cooperating	Cooperative Feeding Behaviour	Reference
Georgia, USA	2	Dolphins herd fish to a sloping bank and thrust themselves onto the bank to capture fish during low tide.	Hoese, 1971
South Africa	unknown	Dolphins herd against shoreline with apparent division of labour patrolling near and offshore.	Taylor and Saayman, 1972
Western Africa	5 to 10	Dolphins swim toward shore as fishermen pound stick on water. Dolphins feed while fishermen net fish.	Busnel, 1973
Indian Ocean	200	Dolphins swim at high speed, herding fish, and performing crisscrossing manoeuvres to trap fish schools.	Saayman <i>et al.</i> , 1973
Louisiana; Baja, CA; near San Clemente Isl., CA	2 to 14	Dolphins herd small schooling fish to tight circle and take turns darting in to catch fish.	Leatherwood, 1975
Northern Gulf of Mexico	3 to 6	Dolphins form a half circle and drive school to shallow water keeping the formation.	Leatherwood, 1975
Texas	unknown	Dolphins swim rapidly in a row underwater, causing a wave at the surface, then swim in different directions and make circular movements. Fish are seen jumping ahead of the dolphins chasing them.	Shane, 1977
Argentina	unknown	Dolphins are seen in spread-school formation (up to 35 m apart) and then herd fish to ocean surface to feed on them.	Würsig, 1979
Gulf of Mexico near Sarasota, FL	20–30	Dolphins converge in 200-m radius, and submerge for 30–90 s. Then large numbers of fish jump at surface and are caught by dolphins, occasionally in midair.	Irvine <i>et al.</i> , 1981
Kino Bay, Mexico	5	Dolphins split into two groups of 2–3 individuals and meet in the middle with fish.	Würsig, 1986; Ballance, 1992
Black Sea	5 to 32	Dolphins move synchronously in a spiral or circle, presumably herding fish, then move into a line, simultaneously dive for 30 s, surface together in a line formation, and dive again for 30–70 s.	Bel'kovich <i>et al.</i> , 1991
Black Sea	3 to 15	Dolphins surround fish and force school to tighten (termed 'carousel'), with dolphins individually swimming through the fish ball (termed 'kettle').	Bel'kovich <i>et al.</i> , 1991
Black Sea	2 to 15	Dolphins herd fish from one side, moving them against shore.	Bel'kovich <i>et al.</i> , 1991

These four dolphins associated relatively closely with each other (SR \bar{x} =0.43, SD=0.29, n=6 pair combinations). They were then compared with an identified community of 28 other dolphins found in the same area (also photographed ≥ 5 times in fully-photographed sightings), termed 'Southern dolphins' in Rossbach & Herzing (in press). The 28 Southern dolphins averaged a SR of 0.19 (SD=0.15, n=378 pair combinations) among members, but the Southern dolphins and the cooperative feeders rarely interacted (SR \bar{x} =0.03, SD=0.04, n=112 pair combinations; 4 cooperative feeders compared to 28 community members; Rossbach & Herzing, in press). Thus, cooperative feeders may be transients, which occasionally move into the study area to feed.

Bottlenose dolphins feed cooperatively in many parts of the world (Table 2), although most reports lack a detailed description of the behaviour. Past reports describe dolphins herding fish toward the surface, the shore, or each other, in contrast to dolphins in the Bahamas which herd fish to the grassy sea bottom, where fish were possibly disoriented. Past reports also describe high-energy movements (e.g., fast swimming, quick movements, leaps, apparent chasing; Saayman *et al.*, 1973; Shane, 1977) by cooperative-feeding dolphins. Although dolphins near Grand Bahama Island swam rapidly during presumed herding of fish, I did not observe high-speed chasing after initial lunging in the circle formation. Dolphins appeared to capture prey easily.

The duration of cooperative-feeding behaviour by bottlenose dolphins is infrequently reported. Cooperative feeders near Grand Bahama Island typically fed for only 3–5 min at a time, before beginning another bout. I observed up to 29 bouts during a single cooperative-feeding sighting that lasted 3 hr 12 min. Fertl & Würsig (1995) observed spotted dolphins (*Stenella frontalis*) feeding in a coordinated manner for over 1 h, and Fertl *et al.* (1997) reported that Clymene dolphins (*Stenella clymene*) fed similarly for 40 min. Killer whales (*Orcinus orca*) in Norway herd fish into a tight ball at the surface and feed for up to 3 h or longer (Simila & Ugarte, 1993). Dusky dolphins (*Lagenorhynchus obscurus*) in the South Atlantic herd fish toward the surface and feed for up to several hours (Würsig, 1986).

Although cooperative feeding has been reported for this species, few detailed descriptions exist. All reports of cooperative feeding among bottlenose dolphins have been opportunistic observations. Future studies concentrating on specific questions concerning cooperation among dolphins may provide a better understanding of its advantages, and offer further insight into dolphin social behaviour and communication.

Acknowledgements

This project was funded by the Oregon State University Endowed Marine Mammal Program. I thank Michael Adam, Terri Herbert, Robin Lawford, Marlene Mendes, Tina Toms, and John Vichnicki for field assistance during cooperative-feeding sightings. I am grateful to Ken Balcomb for vessel use. Expert logistical support was provided by the Wild Dolphin Project, Captains Bob and Dick Rhinehart, and Garvin Greene. Susan Shane and Bruce Mate and two anonymous reviewers improved drafts of this manuscript.

References

- Ballance, L. (1992) Habitat use patterns and ranges of the bottlenose dolphin in the Gulf of California, Mexico. *Marine Mammal Science* **8**, 262–274.
- Bel'kovich, V. M., Ivanova, E. E., Yefremenkova, O. V., Kozarovitsky, L. B. & Kharitonov, S. P. (1991) Searching and hunting behavior in the bottlenose dolphin (*Tursiops truncatus*) in the Black Sea. In: K. Pryor & K. Norris (eds). *Dolphin societies: discovery and puzzles*. pp. 38–67. University of California Press: Berkeley, CA.
- Busnel, R. G. (1973) Symbiotic relationship between man and dolphins. *Transactions of the New York Academy of Sciences, Series 11* **35**, 112–131.
- Fertl, D. & Würsig, B. (1995) Coordinated feeding by Atlantic spotted dolphins (*Stenella frontalis*) in the Gulf of Mexico. *Aquatic Mammals* **21**, 3–5.
- Fertl, D., Schiro, A. J. & Peake, D. (1997) Coordinated feeding by clymene dolphins (*Stenella clymene*) in the Gulf of Mexico. *Aquatic Mammals* **23**, 111–112.
- Hoese, H. D. (1971) Dolphin feeding out of water in a salt marsh. *Journal of Mammalogy* **52**, 222–223.
- Irvine, A. B., Scott, M. D., Wells, R. S. & Kaufmann, J. H. (1981) Movements and activities of the Atlantic bottlenose dolphins, *Tursiops truncatus*, near Sarasota, Florida. *Fishery Bulletin* **79**(4), 671–688.
- Leatherwood, S. (1975) Some observations of feeding behavior of bottle-nosed dolphins (*Tursiops truncatus*) in the northern Gulf of Mexico and (*Tursiops* cf *T. gilli*) off southern California, Baja California, and Nayarit, Mexico. *Marine Fisheries Review* **37**(9), 10–16.
- Norris, K. S. & Dohl, T. P. (1980) The structure and functions of cetacean schools. In: L. M. Herman (ed.). *Cetacean behavior: mechanisms and functions*. pp. 211–261. John Wiley and Sons: New York, NY.
- Rossbach, K. A. (1997) Distinguishing inshore and offshore communities of bottlenose dolphins (*Tursiops truncatus*) near Grand Bahama Island, Bahamas. M.S. thesis, Oregon State University. 121 pp.
- Rossbach, K. A. & Herzing, D. L. In press. Inshore and offshore bottlenose dolphins (*Tursiops truncatus*) communities distinguished by association patterns, near Grand Bahama Island, Bahamas. *Canadian Journal of Zoology*.
- Saayman, G. S., Tayler, C. K. & Bower, D. (1973) Diurnal activity cycles in captive and free-ranging Indian bottlenose dolphins (*Tursiops aduncus* Ehrenburg). *Behaviour* **44**, 212–233.

- Shane, S. H. (1977) The population biology of the Atlantic bottlenose dolphin, *Tursiops truncatus*, in the Aransas Pass area of Texas. M.S. thesis. Texas A&M University. 239 pp.
- Shane, S. (1990) Behavior and ecology of the bottlenose dolphin at Sanibel Island, Florida. In: S. Leatherwood & R. R. Reeves (eds). *The bottlenose dolphin*. pp. 245–265. Academic Press, San Diego, CA.
- Simila, T. & Ugarte, F. (1993) Surface and underwater observations of cooperatively feeding killer whales in northern Norway. *Canadian Journal of Zoology* **71**, 1494–1499.
- Taylor, C. K. & Saayman, C. S. (1972) The social organization and behaviour of dolphins (*Tursiops aduncus*) and baboons (*Papio ursinus*): some comparisons and assessments. *Annals of the Cape Provincial Museums Natural History* **9**, 1–49.
- Würsig, B. (1979) Dolphins. *Scientific American* **240**(3), 136–148.
- Würsig, B. (1986) Delphinid foraging strategies. In: R. J. Schusterman, J. A. Thomas & F. G. Wood (eds). *Dolphin cognition and behavior: a comparative approach*. pp. 347–359. Lawrence Earlbaum Associates: Hillsdale, New Jersey.

